

DRAFT WRITTEN TESTIMONY

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Science Advisory Board (SAB)**

**A JOINT HEARING ON
Reducing Regulatory Burdens, Ensuring the Flow of Commerce and Protecting
Jobs – A Common Sense Approach to Ballast Water Regulation**

**Before the
U.S. HOUSE OF REPRESENTATIVES
COMMITTEE ON TRANSPORTATION AND INFRASTRUCTURE
Subcommittees on Water Resources and Environment and Coast Guard and
Maritime Transportation**

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Introduction

My name is Deborah Swackhamer, and I serve as the Chair of the U.S. Environmental Protection Agency's Science Advisory Board. I am Professor and Charles M. Denny, Jr. Chair in Science, Technology and Public Policy, Hubert H. Humphrey School of Public Affairs, Professor of Environmental Health Sciences, and Co-Director of the Water Resources Center at the University of Minnesota.

The SAB is authorized to provide scientific advice to the EPA Administrator, and one of its roles is to review the quality and relevance of the scientific and technical information being used or proposed as the basis for Agency policies and regulations. I am pleased to offer written testimony on the Science Advisory Board's report: Efficacy of Ballast Water Treatment Systems, and to describe for you its major findings related to ballast water management. This report constitutes an assessment conducted by the SAB's Ballast Water Advisory Panel, whose members included individuals with expertise in statistics, toxicology, risk assessment, aquatic ecology, invasive species, water treatment engineering, marine engineering, and ballast water management. The SAB reviewed and accepted the Panel's report.

Vessel ballast water discharges are a primary source of nonindigenous species introductions and potentially harmful pathogens to marine, estuarine, and freshwater ecosystems of the United States. In recent years, new shipboard treatment systems have been developed and brought to market. This has occurred in response to international guidelines for reducing the impacts of invasive species and in anticipation of new federal rules from the U.S. Coast Guard

and the EPA that would set limits on the number of live organisms allowed in ballast water discharges.

EPA's current Vessel General Permit will expire in December 2013, and a new permit will need to be issued. Last June, EPA's Office of Water asked the SAB to provide advice on technologies and systems to minimize the impacts of invasive species coming from vessel ballast water discharges. More specifically, SAB was requested to provide review and advice regarding whether existing shipboard treatment technologies can reach specified concentrations of organisms in vessel ballast water, how these technologies might be improved in the future, and how to overcome limitations in existing data about ballast water treatment systems in order to improve future assessments. The SAB did not evaluate the risk of invasions as a function of different concentrations of organisms in ballast water discharges because that issue was being addressed by a National Research Council Committee. The SAB did evaluate the ability of existing ballast water management systems to meet numeric discharge standards being proposed by the International Maritime Organization and the US Coast Guard.

To prepare this Advisory report, the SAB reviewed a "Background and Issue Paper" written by EPA's Office of Water and the U.S. Coast Guard. This paper provided an overview of information about major categories of shipboard ballast water treatment technologies and presented proposed ballast water discharge standards drawn from international sources, the USCG, and nine states. In addition, EPA's OW and the public identified information on 51 existing or developmental ballast water management systems (BWMS) for shipboard use. The SAB used this information as the source material for conducting its assessment of ballast water treatment performance and, as requested by EPA, used proposed ballast water discharge standards as the performance benchmarks.

Regulatory context

Ballast water discharges are regulated by EPA under authority of the Clean Water Act (CWA) and by the USCG under authority of the National Invasive Species Act (NISA). In December 2008, EPA issued a Vessel General Permit (VGP) for discharges incidental to the normal operation of commercial vessels, including ballast water discharges. The VGP sets effluent limits for ballast water that rely on "best management practices" (primarily use of ballast water exchange, or BWE) and do not include a numeric discharge limit. The VGP will expire on Dec. 19, 2013. For subsequent iterations of the VGP, the EPA has stated its intention to establish best available technology standards for the treatment of ballast water, once such technologies are shown to be commercially available and economically achievable.

Existing USCG rules governing ballast water also primarily rely on BWE. In August 2009, the USCG proposed revisions to their existing rules to establish numeric concentration-based limits for viable organisms in ballast water. The proposed USCG rule would initially require compliance with a "Phase 1" standard, and, if a practicability review shows it is feasible, it would be followed by a "Phase 2" standard that sets concentration limits at 1000 times more stringent than Phase 1 standards for viable organisms $>10\ \mu\text{m}$ in minimum dimension. Phase 2 standards also set limits on the discharge concentration for bacteria and viruses. Neither Phase 1 nor Phase 2 standards have been finalized. The USCG Phase 1 standards have essentially the

same concentration limits as those adopted in 2004 by the IMO International Convention for the Control and Management of Ships' Ballast Water and Sediments (thus both standards are often referred to in the ballast water community as the "D-2/ Phase 1 standards"). The U.S. is not a Party to the Convention, nor has the Convention yet entered into force. However, manufacturers of BWMS have generally designed their equipment to meet these IMO D-2 standards.

Rigorous sampling and statistical verification of performance is essential

The SAB was asked to respond to charge questions that focused primarily on whether test data demonstrated that BWMS met or "closely approached" proposed standards for discharge and whether they did so "credibly" and "reliably." As benchmarks for performance, the SAB was asked to consider proposed numerical standards as well as narrative descriptions such as "no living organisms," "sterilization," and "zero or near zero" discharge. In order to place its assessments of treatment performance in appropriate scientific context, the SAB first had to consider statistical and sampling issues. While "zero detectable discharge" might initially seem a desirable standard to achieve, it is not statistically verifiable. Further, verification of standards that set very low organism concentrations may require water samples that are too large to be logistically feasible. However, when small sample volumes are used, the probability of detecting an organism is low even when the actual organism concentration is relatively high. These errors depend on the sample volume collected, and the relative errors are much larger for small sample volumes. The SAB concluded that a well-defined, rigorous sampling protocol is essential to assess the ability of ballast water treatment systems to meet different levels of performance. These sampling protocols should include consideration of the spatial distribution of plankton in ballast water. The Poisson distribution is recommended as the model for statistical analysis of treated water samples.

The SAB also concluded that the Phase 1 performance standards for discharge quality are currently measurable, based on data from land-based and shipboard testing. However, current, available methods (and associated detection limits) prevent testing of BWMS to any standard more stringent than Phase 1 and make it impracticable to verify a standard 100 or 1000 times more stringent. New or improved methods will be required to increase detection limits sufficiently to statistically evaluate a standard 10 times more stringent than IMO D-2/Phase 1; such methods may be available in the near future. The SAB also noted these conclusions pertain to evaluating data from land-based and shipboard testing, although the same statistical theory and practice applies to compliance testing by port state control officers.

Charge question 1: Performance of shipboard systems with available effluent testing data

a. For the shipboard systems with available test data, which have been evaluated with sufficient rigor to permit a credible assessment of performance capabilities in terms of effluent concentrations achieved (living organisms/unit of ballast water discharged or other metric)?

Evaluations of technologies are necessarily based on performance information for a given point in time and the development and manufacture of ballast water treatment systems is a dynamic industry. For this assessment, the Panel reviewed information provided by EPA's Office of Water and the public. This information included third party reports, including peer-reviewed articles and publications; information provided directly from individual manufacturers

of BWMS (some included data reports, others provided only Type Approval certificates); and public dossiers submitted to the IMO Group of Experts on the Scientific Aspects of Marine Environmental Protection (GESAMP). This information was prepared or published prior to May, 2010. However, the majority were from 2008 to 2010, reflecting growth in the BWMS industry. This industry continues to be dynamic and, while other BWMS may exist, the Panel considered only those for which information was provided.

From this information, the Panel was able to identify 51 individual BWMS, which can be grouped into 34 categories of treatment technologies. Of the 51 BWMS identified, the Panel concluded that test data and other information for 15 individual BWMS were credible and sufficient to permit an assessment of performance capabilities. Of these 15 BWMS, nine systems (representing individual configurations of five different categories of BWMS) achieved significant reductions in organism concentrations, and were able to comply with the Phase 1 standard. These five categories of BWMS technologies are: Deoxygenation + cavitation; Filtration + chlorine dioxide; Filtration + UV; Filtration + UV + TiO₂; Filtration + electro-chlorination.

b. For those systems identified in (1a), what are the discharge standards that the available data credibly demonstrate can be reliably achieved? Furthermore, do data indicate that certain systems (as tested) will not be able to reliably reach any or all of the discharge standards shown in that table?

The SAB concluded that the same five BWMS categories (listed above) have been demonstrated to meet the IMO D-2 discharge standard, when tested under the IMO certification guidelines, and will likely meet USCG Phase 1 standards, if tested under EPA's more detailed Environmental Technology Verification (ETV) Protocol (EPA, 2010). The SAB acknowledges the significant achievement of several existing BWMS to effectively and reliably remove living organisms from ballast water under the challenging conditions found on active vessels.

The detection limits for currently available test methods preclude a complete statistical assessment of whether BWMS can meet standards more stringent than Phase 1. However, based on the available testing data, it is clear that while five types of BWMS are able to reach Phase 1, none of the systems evaluated by the SAB performed at 100 times or 1000 times the Phase 1 standard.

c. For those systems identified in (1a), if any of the system tests detected "no living organisms" in any or all of their replicates, is it reasonable to assume the systems are able to reliably meet or closely approach a "no living organism" standard based on their engineering design and treatment processes?

The SAB concluded that it is not reasonable to assume that ballast water treatment systems are able to reliably meet or closely approach a "no living organism" standard. Available data demonstrate that current BWMS do not achieve sterilization or the complete removal of all living organisms.

Charge question 2: Potential performance of shipboard systems without reliable testing data

Based on engineering design and treatment processes used, and shipboard conditions/constraints, what types of ballast water treatment systems can reasonably be expected to reliably achieve any of the proposed standards, and if so, by what dates? Based on engineering design and treatment processes used, are there systems which conceptually would have difficulty meeting any or all of the proposed discharge standards?

The SAB found that nearly all of the 51 BWMS evaluated are based on reasonable engineering designs and treatment processes, and most are adapted from long-standing water treatment approaches. However, the lack of detailed information on the great majority of BWMS precluded an assessment of limitations in meeting any or all discharge standards. In particular, the SAB determined that the following data are essential to future assessments: documentation that test protocols were followed; full reporting of all test results; and documentation that rigorous QA /QC methods were followed.

Although several BWMS appear to safely and effectively meet IMO D-2/ Phase 1 discharge standards, the SAB notes that factors beyond mechanical and biological efficacy need to be considered as BWMS technology matures. Several parameters will affect the performance or applicability of individual BWMS to the wide variety of vessel types that carry ballast water. These include environmental parameters (e.g., temperature and salinity), operational parameters (e.g., ballast volumes and holding times), and vessel design characteristics (e.g., ballast volume and unmanned barges).

Charge question 3: System development

a. For those systems identified in questions 1 a. and 2, are there reasonable changes or additions to their treatment processes which can be made to the systems to improve performance?

The SAB defined "reasonable changes" as moderate adjustments that do not fundamentally alter the treatment process. Based on information from the test results provided, such moderate adjustment could be made to treatment processes, although it may add costs and engineering complexity. Examples of moderate adjustments are:

- Deoxygenation + cavitation. It may be possible to reduce the time needed to reach severe hypoxia, to increase holding time under severe hypoxia, and to increase the degree of cavitation and physical/mechanical disruption of organisms.
- Mechanical separation + oxidizing agent. These systems could be optimized by improving mechanical separation, increasing concentration and contact time for oxidizing agents, and adjusting other water chemistry parameters (e.g., pH) to increase oxidizing agent efficacy.
- Mechanical separation + UV. These systems could be optimized by improved mechanical separation and by increasing UV contact time and dosage.

The SAB concluded that moderate adjustments or changes to existing combination technologies are expected to result in only incremental improvements. Reaching the Phase 2 standard, or even 100 times the Phase 1 standard, would require wholly new treatment systems. Such new systems would likely use new technological devices, including those drawn from the water treatment industry; employ multistage treatment processes; emphasize technological process controls and multiple monitoring points; include physical barriers to minimize the potential for cross-contamination of the system; and become part of an integrated ballast water management effort. These new approaches would likely achieve higher performance, but they would require time to develop and test in order to determine their practicality and cost.

b. What are the principal technological constraints or other impediments to the development of ballast water treatment technologies for use onboard vessels to reliably meet any or all of the discharge standards?

Existing ballast water treatment systems have been developed within the context of typical marine vessel constraints, including restrictions on size, weight, and energy demands. The primary impediments to the ability of shipboard systems to meet stringent discharge standards is that treatment processing plants will likely need to be large, heavy, and energy intensive—many existing vessels may be unable to overcome these barriers through retrofitting treatment systems. Meeting more stringent performance standards may require a fundamental shift in how ballast water is managed.

Existing and potential ballast water treatment systems share several common impediments to development: (1) The focus to date has been on engineering the technology with less attention to equally important issues such as training, operation, maintenance, repair, and monitoring. (2) Without an established compliance monitoring and enforcement regime to guide design requirements for technologies, incentives for further innovations are dampened. (3) Facilities properly equipped to test BWMS technologies are few, so increased sharing of data and testing protocols among such facilities is essential. (4) Discharge standards differ domestically and internationally, giving manufacturers multiple standards to target. (5) Meeting more stringent standards will require that treatment systems consistently perform nearly perfectly; a fundamental shift in system design and operational practices would be needed to achieve this level of performance. (6) Once performance tests indicate that a given ballast water treatment system meets Phase 1 standards, further efforts by manufacturers to improve design and efficacy appear to decline.

c. What recommendations does the SAB have for addressing these impediments and constraints?

Clearly defined and transparent programs for compliance monitoring and enforcement are needed to promote consistent, reliable operation of BWMS; such programs do not yet exist. Ideally, vessel crew would have the technological capability to self-monitor BWMS efficacy and make real-time corrections to maintain compliance. BWMS manufacturers should document performance metrics beyond discharge treatment efficacy such as energy consumption and reliability. This would enable vessel operators to select systems that best integrate with their operations. Although meeting significantly higher standards will likely require completely new treatment approaches, the SAB can neither predict which combination of treatment processes

will achieve the highest efficacy nor their ultimate performance. The SAB recommends that one or more pilot projects be commissioned to explore new approaches to ballast water treatment, including tests of ballast water transfer and treatment at an onshore reception facility.

d. Are these impediments more significant for certain size classes or types of organisms (e.g., zooplankton versus viruses)? Can currently available treatment processes reliably achieve sterilization (no living organisms or viable viruses) of ballast water onboard vessels or, at a minimum, achieve zero or near zero discharge for certain organism size classes or types?

Shipboard impediments apply to all size classes of organisms and specified microbes. Some treatment systems or combinations are more effective for treating larger organisms and others for treating unicellular organisms. The technology exists to remove or kill the great majority and in some cases, to remove nearly all organisms $\geq 50 \mu\text{m}$ from discharged water. Given the volumes of water involved, onboard sterilization of ballast water is not possible using current technologies. It is not possible to verify zero (sterilization) or near-zero discharge. Such values cannot be measured in a scientifically defensible way.

Charge question 4: Development of reliable information

What are the principal limitations of the available studies and reports on the status of ballast water treatment technologies and system performance and how can these limitations be overcome or corrected in future assessments of the availability of technology for treating ballast water onboard vessels?

Existing information about ballast water treatment is limited in many respects, including significant limitations in data quality, shortcomings in current methods for testing BWMS and reporting results, issues related to setting standards and for compliance monitoring, and issues related to test protocols, including the use of surrogate indicators.

Principal limitations of available data and protocols

Data are not sufficiently compatible to compare rigorously across BWMS because standard test protocols have been lacking. The procedures provided in the 2010 EPA Environmental Technology Verification (ETV) Protocol, which focuses on verification of BWMS performance, will improve this. Currently, reporting of test failures during type approval testing is not required, although some independent test facilities do report failures. This requirement should be uniform across research and other test facilities so that it is possible to draw conclusions about the consistency or reliability of BWMS performance.

Clear definitions and direct methods to enumerate viable organisms are missing for some organisms and are logistically problematic for all size classes, especially nonculturable bacteria, viruses, and resting stages of many other taxa. Methods to enumerate viruses are not included in the proposed USCG Phase 2 standard. The important size class of protists¹ $< 10 \mu\text{m}$ have not

¹ Protists refers to various one-celled organisms classified in the kingdom Protista, and which includes protozoans, eukaryotic algae, and slime molds.

been considered adequately in developing guidelines and standards, although some SAB members felt that other measurements may indicate activity in that size class.

Alternatives to shipboard treatment of ballast water

The SAB found that because of the lack of an overall risk management systems approach, data on the effectiveness of practices and technologies other than shipboard BWMS are inadequate. Insufficient attention has been given to integrated sets of practices and technologies to reduce invasion or pathogen risk by (1) managing ballast uptake to reduce the presence of invasive species, (2) reducing risk of introducing invasive species through adjustments in operation and ship design to reduce or eliminate the need for ballast water, (3) development of voyage-based risk assessments and / or risk management approaches, and (4) options for reception facilities for onshore treatment of ballast water. The SAB concludes that combinations of practices and technologies are potentially more effective and cost-efficient than sole reliance on shipboard ballast water treatment technologies.

Use of reception facilities for the treatment of ballast water appears to be technically feasible (given generations of successful water treatment and sewage treatment technologies), and is likely to be more reliable and more readily adaptable than shipboard treatment. Existing regional economic studies suggest that treating ballast water in reception facilities would be at least as economically feasible as shipboard treatment. However, these studies consider only that vessels call at those regional facilities; if vessels also call at ports outside the region without reception facilities, they would need a shipboard BWMS. The effort and cost of monitoring and enforcement needed to achieve a given level of compliance is likely to be less for a smaller number of reception facilities compared to a larger number of BWMS.

Recommendations to overcome present limitations

As illustrated in the 2010 EPA ETV protocol, testing of BWMS in a research and development mode should be distinct from testing for type approval certification and for verification. Certification testing should be conducted by a party independent from the manufacturer with appropriate, established credentials, approved by EPA/USCG. Test failures and successes during type approval testing should be reported and considered in certification decisions. A transparent international standard format for reporting, including specification of quality assurance / quality control (QA/QC) protocols and a means to indicate QA/QC procedures were followed during testing, are needed. In addition, EPA should develop metrics and methods appropriate for compliance monitoring and enforcement as soon as possible. The SAB suggests a practical step-wise approach in order to cost effectively increase the likelihood of detecting non-compliance. This could include a sequence of compliance reporting, inspections, indirect measures of system performance, indirect measures of non-compliance, and ultimately direct measures of live organisms made by specially trained personnel using rigorous QA/QC assurance methods.

Limits for selected protists $< 10 \mu\text{m}$ in minimum dimension should be included in ballast water discharge standards and in BWMS test protocols. Suitable standard test organisms should be identified for bench-scale testing, and surrogate parameters should be investigated to

complement or replace metrics that are logistically difficult or infeasible for estimating directly the concentration of living organisms. Representative "indicator" taxa (toxic strains of *Vibrio cholerae*; *Escherichia coli*; intestinal Enterococci) should continue to be used to assess BWMS. Estimates of the removal of harmful bacteria will be improved when reliable techniques become available to account for active, nonculturable cells as well as culturable cells.

EPA should conduct a comprehensive analysis comparing biological effectiveness, cost, logistics, operations, and safety associated with both shipboard BWMS and reception facilities. If the analysis indicates that treatment at reception facilities is both economically and logistically feasible and is more effective than shipboard treatment systems, it should be used as the basis for assessing the ability of available technologies to remove, kill, or inactivate living organisms to meet a given discharge standard. In other words, use of reception facilities may enable ballast water discharges to meet a stricter standard.

Ballast water management should be implemented using a risk-based systems approach

The SAB recommended that any ballast water management strategy to decrease the rate of successful invasions by nonindigenous species or introduction of pathogens be part of an overall risk-based management plan. Decisions on approaches to ballast water management should be viewed in the context of risk management and should: (1) recognize the stochastic and non-linear nature of the invasion process, (2) clearly define the management goals, and (3) evaluate the effectiveness of BWMS within the context of other sources of nonindigenous species and other organisms found on the vessel and in the treatment system, and with respect to specific receiving habitats. Each step from ballasting to deballasting, including the choice of procedures and the choice of treatment technologies, contributes to the probability of an invasion occurring. Hazard Analysis and Critical Control Points (HACCP) has been demonstrated to be an effective, flexible, and practical risk management tool in a variety of situations. It is currently in wide use in the food safety industry and could be applied to ballast water management. HACCP, or other risk management tools, could be used to guide priorities, such as deploying ballast water treatment technologies or to establish schedules for compliance monitoring focused on high-risk vessels or high-risk voyages.